FEATURE 8: PURCHASE EXISTING GROUND WATER RIGHTS

Description

There exists some potential to purchase ground water from willing sellers and transfer, or re-appropriate, the ground water to municipal use. For this estimate, re-appropriation is considered to involve the purchase of the irrigated land and therefore the water right. This irrigation water right may need to be “abandoned” and the new owner (a municipality or water department) will apply for a new permit near the same point of diversion as the former irrigation permit, but under municipal use. A new well will be installed for municipal withdraws throughout the entire calendar year. This estimate is provided for cost and quantity purposes to evaluate this feature. The aquifers considered here are the larger ones that support a fairly large number of irrigation withdrawals. This estimate does not include new appropriations above the existing amounts. A pipeline layout, based on a somewhat random purchase of irrigation water permits, has been completed to provide some magnitude of costs on the collection and transmission of the ground water to the city area. The delivery point is considered to be the river channel just upstream of existing municipal diversion sites. Collection pipelines have been sized for cumulative flow collection from new extraction wells constructed on the lands within the ownership boundaries of purchased irrigation rights.

The Sheyenne Delta Aquifer

The Sheyenne Delta Aquifer is one of the largest surficial aquifers in the Red River Valley. Its thickness, lithology, and hydrology are described in the attached SWC memo. Two of the significant properties of this aquifer are the shallow water table, and the sandy surface soils which enhance the aquifer recharge. The Sheyenne National Grasslands cover a large surface area of the aquifer, and the existence of the threatened western prairie fringed orchid presents a special set of challenges when considering future ground water withdrawals from the area. It is also important to note that this aquifer helps maintain, and in fact enhances, the flows of the Sheyenne River through the aquifer area. The Sheyenne River between Lisbon and Kindred has been shown to be a gaining reach of river due to the inflow of groundwater from the Sheyenne Delta Aquifer (Paulson, 1964). One study measured increases of river base flow between 15.1 and 28.8 cfs from October through February. Other estimates of discharge to the Sheyenne River (Armstrong, 1982) are from 1 to 3 inches of the annual aquifer recharge, which results in an estimated discharge volume from 40,000 to 120,000 acre-feet per year. This is significant in that proposals to increase ground water withdraws to serve municipal or industrial sites may diminish existing river flows.

The aquifer and geologic conditions could also be further investigated to determine an expected yield limit for the Sheyenne Delta Aquifer. The sandy loam surface soils of the aquifer have fairly high permeability and therefore readily accept rainfall infiltration. Based upon this soil type, Radig, March 1994, uses the general estimate for aquifer recharge of 4.2 inches per year. The amount of recharge has been estimated to be as high as 8 inches per year (Armstrong, 1982) and as low as 3.05 inches per year (COE, 1985).   Future investigations could address both natural and artificial recharge of the aquifer. Use of artificial recharge, however, would require first a lowering of the water table to create some aquifer storage space, and then a water source to be used to recharge the aquifer. The results of the HYDROSS models indicate that during an extended drought there is no available excess water in the Sheyenne River basin, and without either additional surface storage or imported water, a supply for recharge would not be available except for short duration higher flows during spring runoff.

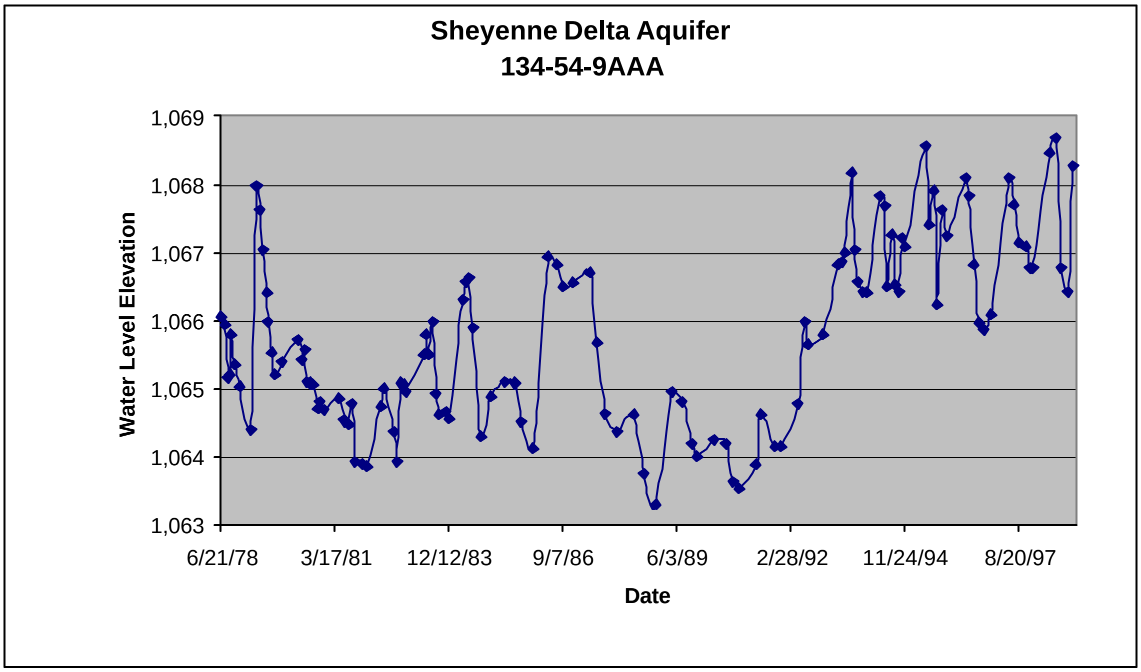
Existing Aquifer Uses

Information from the database of groundwater permits for the Sheyenne Delta aquifer show annual use and permitted withdrawal rates for individual wells. As of 1998, the total of all existing irrigation permits from the Sheyenne Delta Aquifer amounts to an appropriation of 18,982 ac-ft annually. This amount of annual withdraw for irrigation purposes takes place sometime during the May through September time frame. An additional 1,300 ac-ft per year has been appropriated for rural water system wells.

Additional ground water discharge takes place through direct evaporation from surface depressions that intersect the water table and through transpiration of plants that have access to moisture provided by the aquifer. There is no estimate for this evaporation and transpiration, however, due to the shallow water table and sandy surface soil, it is assumed to be a significant amount. Hydrographs of the ground water levels are available only for a limited recent time period. They show seasonal fluctuation with water generally between 2 and 15 feet from the ground surface. No declining trends are evident, which indicates that for the recent (non-drought) conditions, annual discharge and recharge are balancing. The following hydrograph shows that since 1992 the aquifer at this location has been experiencing increasing ground water storage. This hydrograph does not depict conditions for the entire aquifer system, nor does it give any indication what would happen during a sustained drought.

Future Potential New Permits

New aquifer pumping permits would require site specific proposals and studies to evaluate any potential negative impacts on the existing permit holders. Additional impacts to the Sheyenne National Grassland and the habitat for the western prairie fringed orchid would also need to be assessed. Due to the recent difficulty surrounding the conditional approval of additional new water permits for rural water use, the likelihood of obtaining an entirely new ground water use permit of any substantial size is slim. Therefore, the future utilization of Sheyenne Delta aquifer water for municipal purposes will be estimated based upon purchase of existing irrigated land and water rights and the transfer of that use to municipal purposes.



Transfer of Existing Irrigation Permits

The potential transfer, or reappropriation, of irrigation water to municipal water was considered through a “willing seller” type of an approach. The amount of ground water that might be made available is estimated as follows:

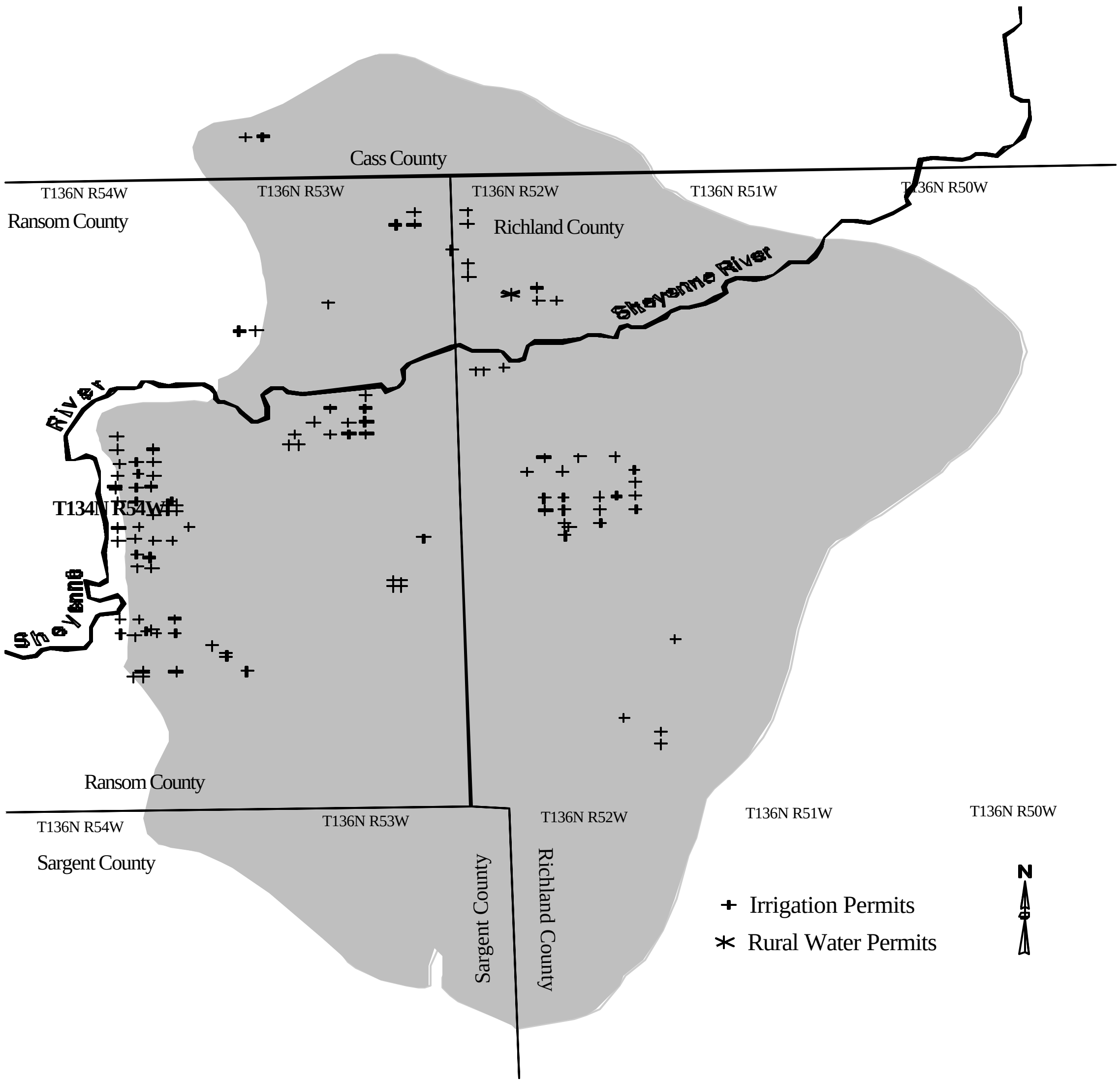
1) Assume the "willing seller" approach would be successful only with greater than market value land purchase offers

2) Assume 33% would be willing to sell their irrigated land and the water rights (1 out of 3 landowners) at 150% of market value

3) Assume municipal buyers would only be interested in larger irrigation appropriations (150 ac-ft per year or more) for withdraw and conveyance consolidation

4) Assume the irrigation to municipal transfer or reappropriation to be 60% of the existing irrigation appropriation

The irrigation appropriations of the Sheyenne Delta aquifer, for individual permits of 150 ac-ft per year or more, correspond to a total of 9,655 irrigated acres. These acres have a total ground water appropriation amount of 14,165 ac-ft per year. Therefore, the average annual appropriation for these irrigation rights is 1.47 ac-ft per acre. Assuming 33% of this land could be purchased, the resulting irrigation acreage available for transfer would then be 3,215 acres. The estimate for the ground water appropriated to these acres is 4,726 acre feet per year (3,215x1.47), however, this water would not directly transfer to a municipal permit. The reduction in appropriation for the transfer of irrigation use to municipal use is expected for several reasons. Irrigation users seldom actually use more than 50-60% of their appropriated amount, therefore the actual managed withdraw on the aquifer is much less than the full appropriated amount. Municipal pumping represents a more steady monthly groundwater withdrawal which would not vary with wet and dry climatic cycles as much as agricultural uses would. This reduction percentage has not been established since there has not been any completed case of this type of water transfer within the State of North Dakota. The reduction is expected for the purposes of long term sustainable management of the aquifer systems for the benefit of their various users. The transfer reduction (assumed 60% but could likely be less) would result in a net ground water supply available for municipal uses of 2,835 acre-feet per year. This 60% transfer amount is established as the *maximum annual* withdrawal and the actual use by the municipality could be less, depending upon the demands of the year. This 2,835 ac-ft could be collected and transported to the Fargo/West Fargo area or utilized locally by the rural water systems.



Sheyenne Delta Aquifer

An estimate has been completed to determine the cost of purchasing one-third of the irrigated land based on a somewhat random selection of existing larger permits. The estimate shows the general magnitude of cost for land purchase, well installation, pumping, collector piping, booster pump, and transmission piping to the Sheyenne River at Horace. The result of this exercise shows that an annual yield of approximately 2,600 ac-ft could be expected at a maximum flow rate of about 1,750 gpm.

Estimates have not been completed to provide water directly into the Fargo treatment plant, but rather to the Sheyenne River near Horace. Water added to the river flow at this location has a relatively short distance to flow to the Fargo pump diversion. Future study must include some water quality and compatibility analysis, however, for this level of estimate the groundwater is assumed to be compatible with the surface water and the operations of the existing Fargo water treatment plant. This assumption

has been made since ground water from the Sheyenne Delta Aquifer current flows into the Sheyenne River under natural conditions.
Using the future 2050 low and 2050 high population projections for the rural water systems, the amount of water needed to meet the projected 2050 shortages of Southeast and Cass Rural Water System ranges from 2,058 to 3,270 ac-ft per year. Based upon the above assumptions, this shortage is in the range that could feasibly be met by willing sellers and water rights transfers, or reappropriation, in the Sheyenne Delta aquifer. Since the existing rural water systems utilize ground water for their supply, they could expand into this ground water supply as their need grows. This water supply would not require a change in treatment methods and techniques used by the rural water system which would be necessary if they were to expand and use a surface water supply. The cost of the land purchases, new wells, collector piping, and a storage reservoir can be used to determine a relative cost of this feature. The cost of expansion of the rural water system treatment plant has not been determined.

The Page/Galesburg Aquifer

The lithology and hydrology of the Page/Galesburg aquifer system are described in the attached SWC memo. This aquifer is located in an area where it could be utilized by the larger municipal area of Fargo, and West Fargo. Currently, Traill County Rural Water and Cass Rural Water are using the aquifer for a water supply. Irrigation development has been somewhat limited to the aquifer areas that are capable of larger well yields. Estimates of the amount of recharge range from 1 to 3 inches per year over the 400 square mile surface area.

Existing Aquifer Uses

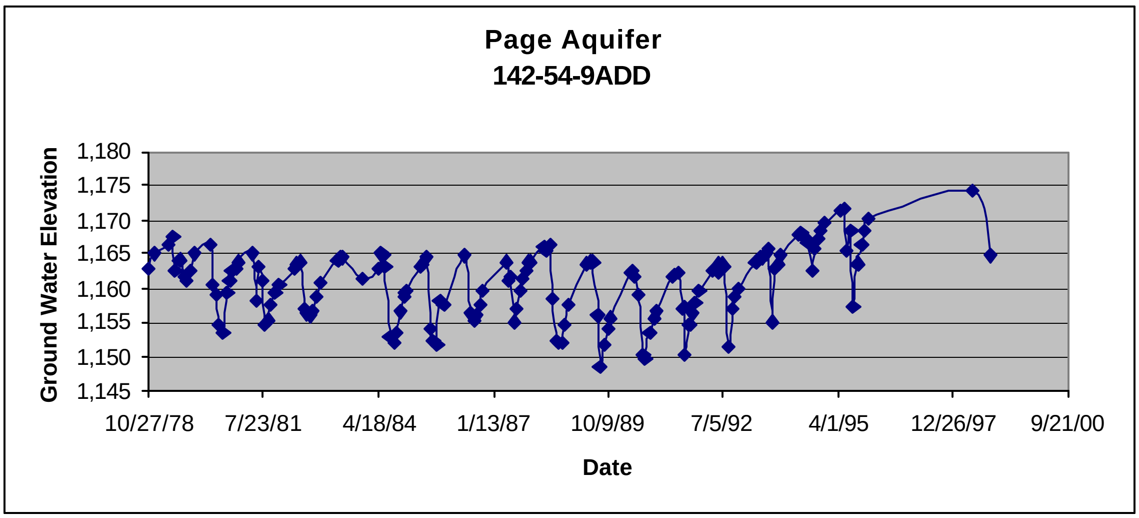
As of 1998, irrigation appropriations from the aquifer total 15,240 acre-feet per year. Municipal and rural water appropriations total 1,146 acre-feet per year. For the purposes of this study, these existing uses are assumed to continue. During a drought period, some water level declines would be expected, however, subsequent wet years would be expected to refill the aquifer. Cass Rural Water and Traill County Rural water have wells in this aquifer and treat and distribute this water to their customers.

The following hydrograph displays the seasonal fluctuations of the water levels at one location, and shows the aquifer response to increased annual precipitation since 1992. The hydrograph represents only one location in the aquifer system, however, other hydrographs show similar cyclical fluctuations and do not indicate long term declining trends that would be associated with over-use of the ground water supply.

Future Potential New Permits

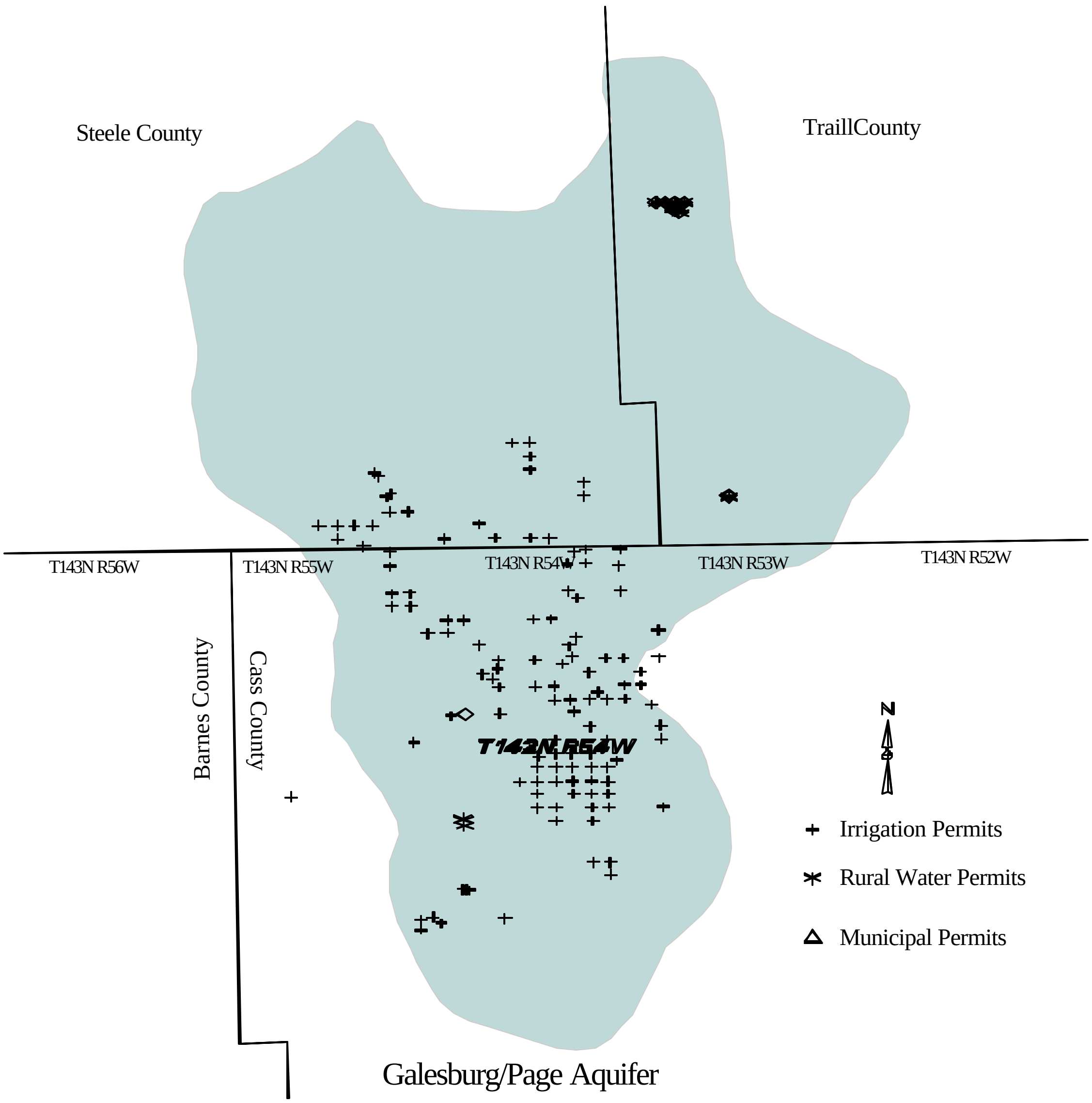
An indication of the amount of ground water available in the aquifer can be gained by comparing the amount of annual recharge to existing appropriations. Using a conservative estimate of 1 inch of recharge per year over the entire 400 square mile surface area, the annual recharge would be 21,330 ac-ft. This could be compared to the existing appropriations of 16,385 ac-ft. This is not an estimate of "safe yield," but does provide an elementary comparison of the amounts appropriated and the amount of annual recharge in the aquifer (77%).

Water rights transfers or reappropriation rather than new permits could be considered for the Page/Galesburg aquifer system. Using the same assumptions given for the Sheyenne Delta aquifer, a potential of 4,400 irrigated acres could be considered as “willing seller” purchases. This acreage would provide a potential water right transfer or reappropriation to municipal use of 1,900 ac-ft. This ground water could be considered for collection and transfer to the Fargo/West Fargo municipal area or for transfer to the rural water system currently using this aquifer.



The rural water districts that use this ground water will likely apply for future expansion of their ground water appropriations, as their needs require. Cass Rural Water future shortages are in the range of 1,560 to 2,420 ac-ft per year. Part of this shortage could occur in the areas close to the Page aquifer and it would be logical for their expansions to include future additional ground water from the Page aquifer. The Dakota Water Users are projected to have future shortages between 620 and 880 ac-ft per year. Dakota Water Users have existing wells in the Page aquifer and would likely be expected to request future expansion in the aquifer as their need grows. Traill County Water Users have wells in the Page aquifer and have a projected future shortage of 60 ac-ft per year. This amount of water would again be easily expected from the Page aquifer either through a new well or an increase in production from existing wells. These three rural water systems could create a future demand between 2,240 to 3,360 acre-feet. This demand represents an increase of 14% to 20% over the total current annual appropriations of the aquifer if new permits are being considered.

The Page/Galesburg aquifer could likely provide some additional future water supply. This would require some site specific investigations to develop production wells in locations that would not unduly impact other existing users. The aquifer is generally more suited to provide rural water systems with added water than it would be for the Fargo/West Fargo municipal area. A cost estimate for transfer or reappropriation has been completed and includes multiple wells, collection pipelines, and transmission pipelines to the Fargo/West Fargo municipal.



Galesburg/Page Aquifer

The Elk Valley Aquifer

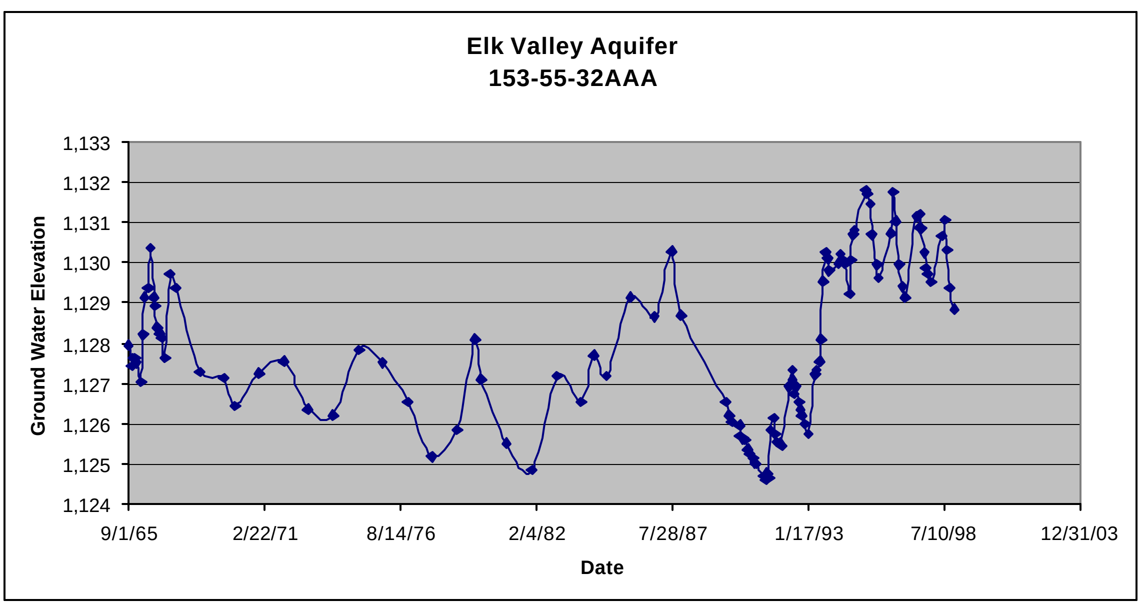
A general description of the lithology and hydraulic properties of the Elk Valley aquifer is given in the attached SWC memo. This aquifer is located in the north central part of the Red River Valley. This location makes access to the Fargo municipal area less of a possibility for a future water supply source. However, there is the possibility of supplying additional ground water to local rural water systems or some water to the city of Grand Forks in exchange for water stored in Lake Ashtabula. This exchange would allow Grand Forks to utilize ground water and release an equal amount of its storage water to be used by Fargo or other cities that have a severe shortage.

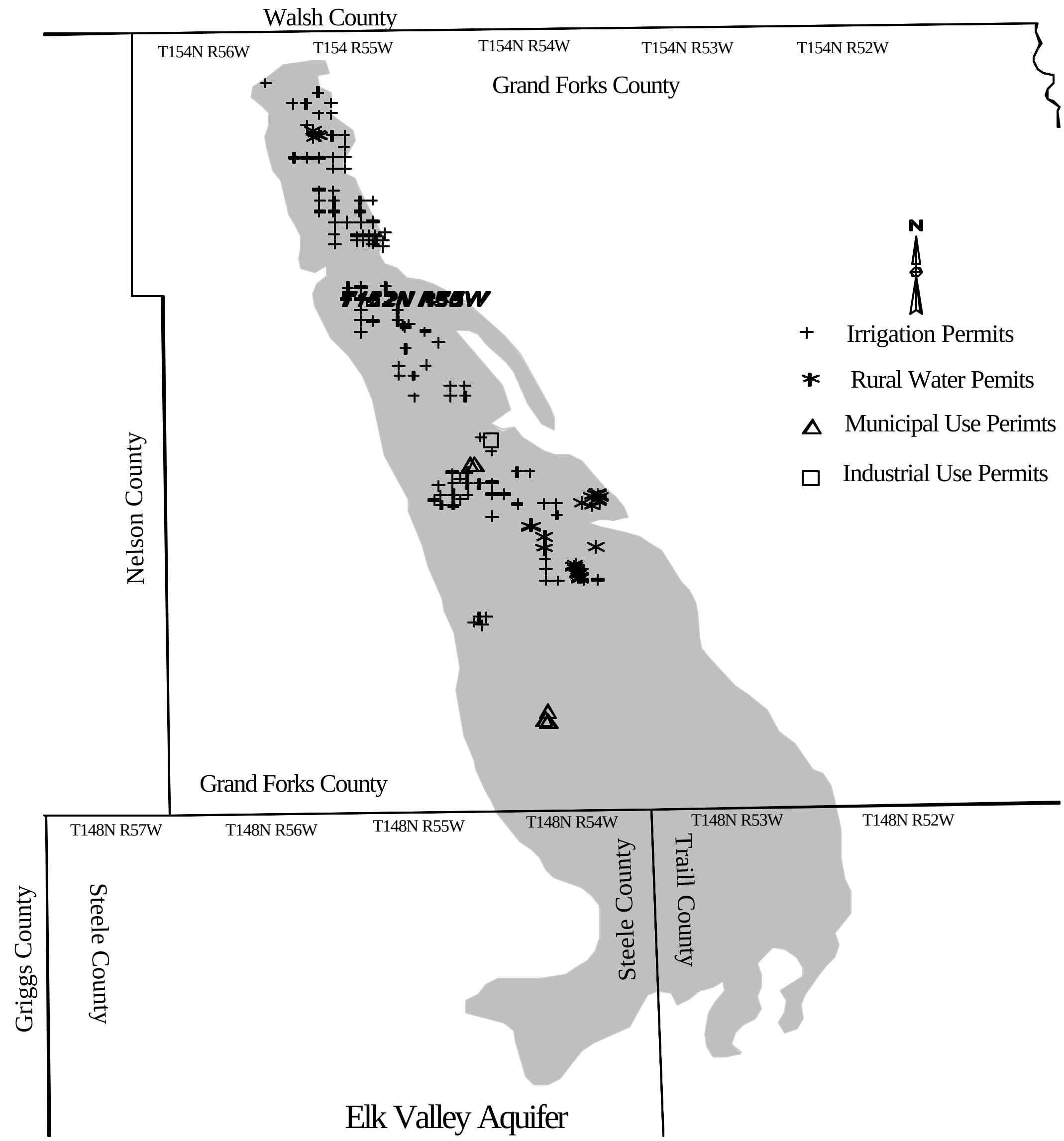
Existing Aquifer Uses

The primary user of the Elk Valley aquifer is irrigation. At the end of 1998, irrigation permits total 15,635 ac-ft per year and an additional 2,904 ac-ft per year are appropriated to municipal and rural water uses. Two rural water systems and several small individual communities utilize the Elk Valley aquifer. The following hydrograph shows an example of the general ground water fluctuations in the aquifer during recent years at one location.

Future Potential New Permits

As noted in the SWC memo, there are additional requests pending for irrigation appropriations. These requests would be first in line for new appropriations. The two rural water systems using the Elk Valley aquifer are Grand Forks-Traill and Tri-County Water Users. The estimated future combined shortages for these two systems ranges from 1,490 to 3,020 ac-ft per year. To meet these shortages with additional withdrawals from the Elk Valley aquifer would require an increase in ground water appropriation from 8% to 16% per year. Due to the size of this aquifer, and the amount of existing appropriation, the SWC memo indicates that it would not be a good candidate for future municipal withdrawals. Further investigation would be needed to determine if the aquifer would be able to sustain expansion to supply future additional water to the rural water systems. Future studies could include modeling to help determine the impact of a drought period on the ground water supply.





Potential water rights transfers or reappropriation rather than new permits could be considered for the Elk Valley aquifer system. Using the same assumptions given for the Sheyenne Delta aquifer, 5,500 acres could potentially be considered as “willing seller” purchases. This acreage would provide a potential reappropriation or transferred to municipal use of about 3,000 ac-ft per year. An estimate of cost has been made for the withdraw and collection of this amount of water. An estimate has also been made to include a transmission line to the Grand Forks municipal area. Due to the location, amount of water available, and the transmission cost, the aquifer is generally more suited to provide rural water systems with added water than it would be for the Grand Forks municipal area.

<u>The Fordville Aquifer</u>

The Fordville aquifer is a much smaller aquifer than the Sheyenne Delta, Page, or Elk Valley aquifers, and is located on the north end of the Elk Valley aquifer. (See Aquifer Location Map). All but one of the existing observation wells show stable or slightly rising ground water levels since 1990. These indicate that existing uses, under the conditions since 1990, are not depleting the aquifer.

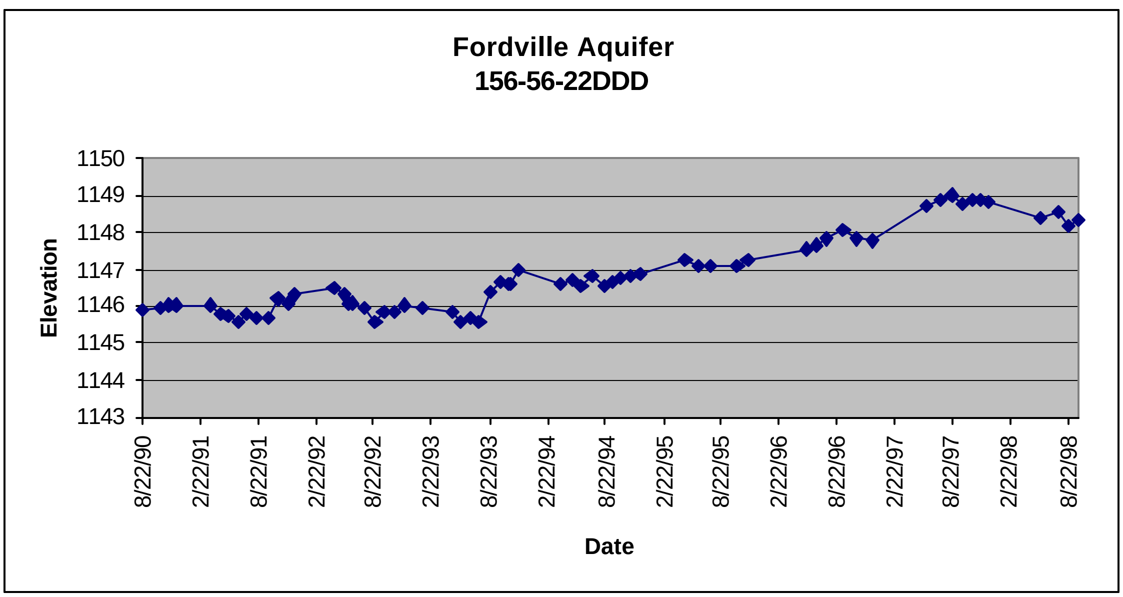
Existing Aquifer Uses

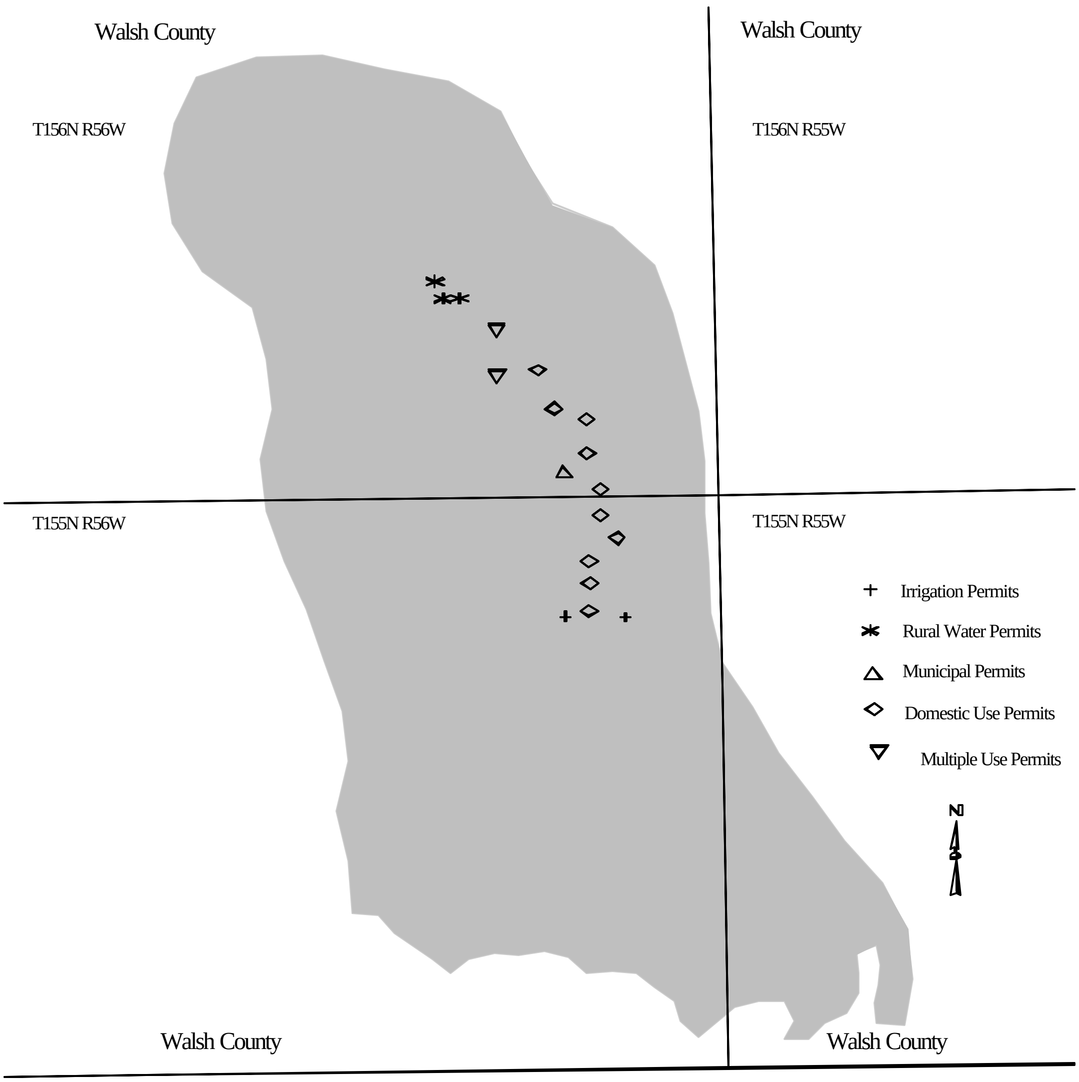
Walsh Rural Water and the city of Minto are using this aquifer for their municipal supplies. Only one irrigation permit is listed for a total of 201 ac-ft. At the end of 1998, the total appropriation from this aquifer is 1,590 ac-ft per year. The following hydrograph shows general ground water fluctuations at one location during a recent time span.

Future Potential New Permits

Due to the relatively small size, and the amount of existing municipal use, new permits would require some site specific investigation in order to protect the existing users. Walsh Rural Water has projected future shortages that range from a low of 80 ac-ft to a high of 200 ac-ft per year. This shortage could be met by an expansion of 5% to 12% of the existing Fordville aquifer appropriations.

The Fordville aquifer could likely provide the needed water supply for the future needs of Walsh Rural Water. Additional studies to determine the aquifer reaction to existing and future uses, and a drought scenario could be included with any future computer modeling. Identification of the amount of aquifer recharge could also be attempted in follow-up studies.

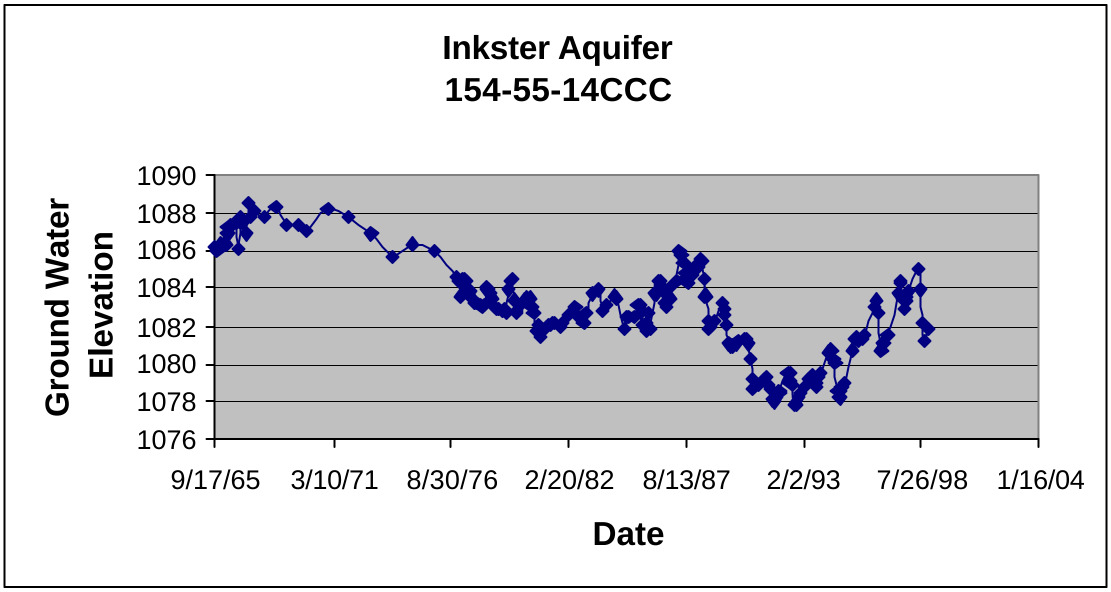




Fordville Aquifer

The Inkster Aquifer

The general lithology and hydraulic characteristics of the Inkster aquifer are given in the attached SWC memo. This aquifer is fairly small and is also located in the north central part of the Red River Valley. The size of the aquifer is given as 12 to 15 square miles, which is an area of approximately 8,300 acres.



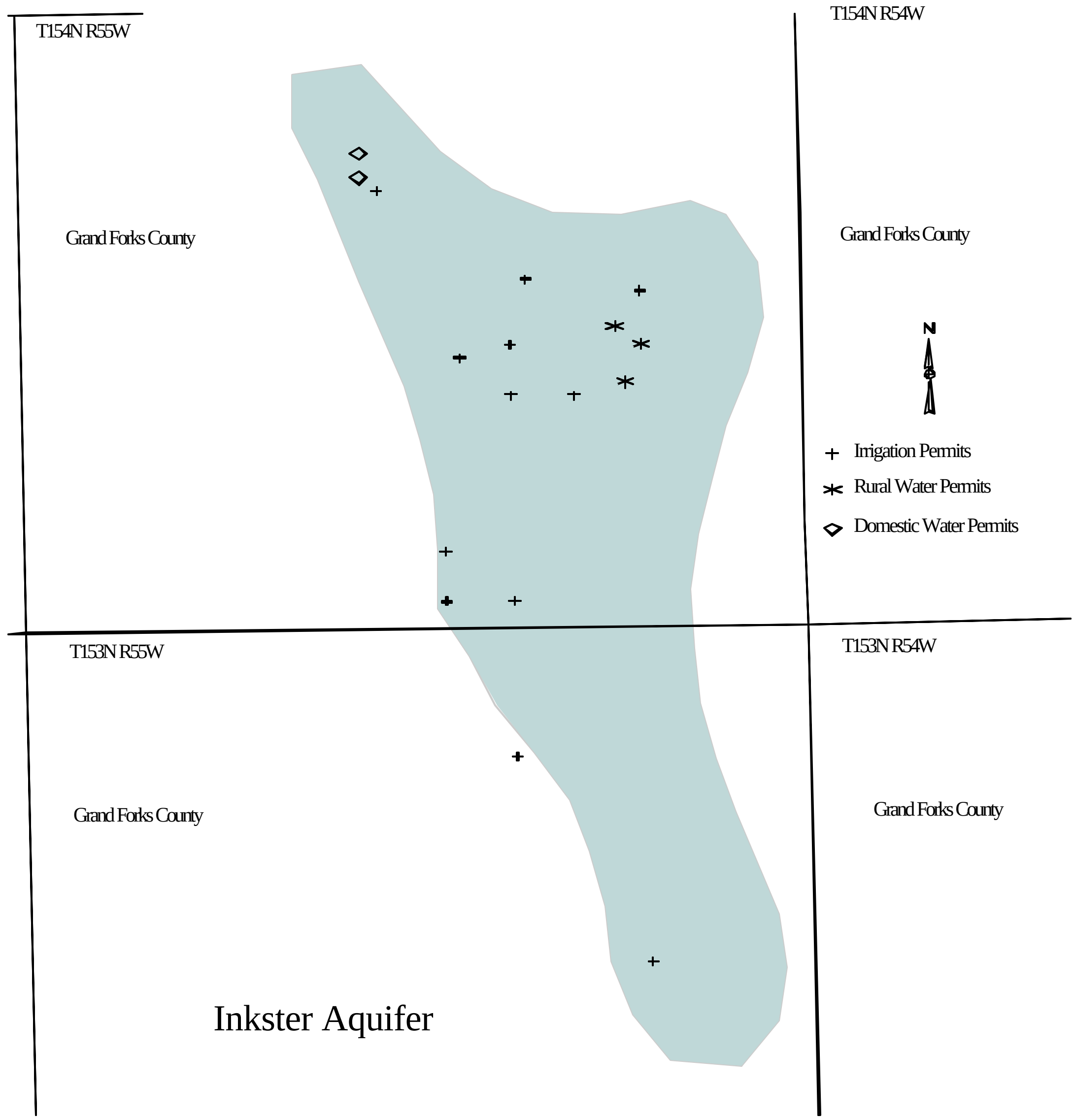
Existing Aquifer Uses

At the end of 1998 the aquifer appropriations total 3,590 ac-ft for all irrigation and rural and municipal water. When compared to the aquifer area of about 8,300 acres, this corresponds to an average annual recharge of 5 inches of infiltration. This is in the range of the annual recharge estimated for the Sheyenne Delta aquifer (3 to 8 inches).
The Agassiz Water Users have ground water supply wells in the Inkster aquifer. The following hydrograph shows ground water fluctuations at one location in the aquifer.

Future Potential New Permits

The small size, and the amount of existing annual appropriation, makes this aquifer a poor candidate for potential new permits. The projected future shortages for Agassiz Water Users are from 3 to 50 ac-ft per year. This could be met by future appropriations of about a 1% increase over the total current appropriations. This is a relatively small amount of additional water, however, due to the amount of water currently appropriated from the aquifer, future site specific investigations would likely be needed.

This aquifer is not a candidate for future water supply expansions. The possibility of an additional allocation for Agassiz Water Users should be considered as their need grows. Future studies or follow-up investigations could be conducted to determine the overall impact of the existing and future ground water withdrawals. These future studies could include some numeric modeling to determine ground water supplies under a drought condition scenario.



Rural Water System Supply

Rural water system supplies are discussed in more detail here because they are all (with the exception of Langdon) ground water dependent. The rural water systems have multiple wells at various locations and even in different aquifer systems. The rural water systems were not included in the HYDROSS modeling since HYDROSS is a surface water model. Future predictions have been made for the rural water service areas, and those future demands were compared to existing water permit appropriations. Where the future estimated demand was greater than the existing appropriation, a shortage has been listed. It has been assumed that the rural water providers will be able to utilize their total water right appropriation.

The estimated future service for the rural water systems is based on expansion to serve all of the population within their boundary. Since the estimated future populations have been based on a "high" and a "low" estimate of growth in the Phase 1, Part A report, the estimates for the future rural water needs also contains a high and a low estimate. The estimates for the individual rural water system shortages are as follows:

Table 8.1
Shortage Estimate

Rural Water System	2050 Low Shortage Estimate Acre-Feet per Year	2050 High Shortage Estimate Acre-Feet per Year
Agassiz Water Users	3	51
Barnes Rural Water	0	0
Cass Rural Water	1,558	2,418
Dakota Water Users	622	875
Grand Forks-Traill Water Users	1,093	2,551
Langdon Rural Water	214	320
North Valley Water Ass...	0	0
Southeast Water Users	500	852
Traill County	63	63
Tri-County Water Users	397	468
Walsh Water Users	83	199
Ransom Sargent	251	299

Surface water supply and shortage predictions have been completed using the HYDROSS model simulations. Shortage data from all HYDROSS simulation runs is summarized as follows:

Table 8.2
HYDROSS Shortages

Run Name	M & I Total Shortage, Ac-Feet	2050H Rural Water plus M&I
RIMRS50	0	8096
RCKMF0R	0	8060
RCKMH0R	0	8096
RCNIMRF	12730	20826
RCN19F0	13330	21426
RCNKINE	13450	21546
RCNKME	13750	21846
RCKME0R	15150	23246
RIMRE50	16020	24116
R19F50	16360	24456
RIMPS50	16360	24456
RKIN50F	16360	24456
RKIN50E	24610	32256
RCN19E0	27320	35416
RCNMAPE	27460	35556
RCON00	28650	36746
RMAP50F	37560	45656
RMAP50E	37560	45656
RCON50	37750	45846
R00K50	43000	51096
R19E50	43600	51696
RIRR50C	42960	51056
RRUC50A	47470	55566
R30K50	47800	55896
P30K50	74420	82516

The fourth M&I shortage listed (12,730 acre-feet) represents shortages at Moorhead, West Fargo, and New Industry 3 and 5. This can be used to compare the magnitude of M&I shortage with the previous table of rural water shortages. Combining this shortage with the projected shortages for Cass Rural Water, Southeast Water Users, and Ransom-Sargent Rural, the total unmet demand is in the range of 15,040 to 16,300 acre-feet. At this point, it is questionable whether an *added* 15,000 to 16,000 acre-feet is practical as a stand alone ground water supplemental supply. For comparison, the current *total annual appropriations* from the major aquifers in the Red River Valley are: 19,896 ac-ft from Sheyenne Delta; 18,539 ac-ft from Elk Valley; 19,000 ac-ft from Spiritwood (that portion in the Red River Valley); 16,385 ac-ft from Page/Galesburg; 3,586 ac-ft from Inkster; and 1,791 ac-ft from the Fordville. An extensive and detailed study of the impacts of that sizeable additional ground water withdrawal would be needed in order to determine any potential feasibility.

For this estimate, the following aquifers have been considered for potential rural or municipal water supply augmentation.

Spiritwood Aquifer	6,660 ac-ft from new appropriations
Sheyenne Delta Aquifer	2,600 ac-ft from irrigation transfers
Page/Galesburg Aquifer	1,940 ac-ft from irrigation transfers
Elk Valley Aquifer	3,000 ac-ft from irrigation transfers
Total	14,200 ac-ft per year

Summary and Conclusions

The amount of ground water that could become available for future rural and municipal purposes has been estimated, but only after consideration of several significant assumptions. The assumptions were necessary in order to "narrow" the range of possibilities and unknowns. These assumptions allow for a rough estimate of the amount of ground water that may be available to offset these identified future shortages. The assumptions also allow some degree of cost estimation that can be used when comparing these types of future water supplies with other water supply features.

The shortage predicted for the municipalities cannot be fully met by aquifer pumping alone. Therefore, optional water supplies must be considered in order to provide the year 2050 water supply. The location of the ground water aquifers, and costs associated with this supply, such as transmission lines and water treatment needed, lead to the conclusion that the aquifers could best be utilized by the rural water systems.

The combined aquifer supply and rural water systems shortage needs can be estimated as:

Aquifer and "Available Water"	Rural Water Year 2050"High" Shortage
Sheyenne Delta Aquifer water available from transfer or reappropriation: 2,600 ac-ft/yr	Cass Rural Water = 1,450 ac-ft Southeast Water Users = 850 ac-ft Ransom-Sargent Rural Water = 300 ac-ft Combined Future Need = 2,600 ac-ft/yr Balance = -0-
Page/Galesburg Aquifer water available from transfer or reappropriation: 1,940 ac-ft/yr	Cass Rural Water = 970 ac-ft Traill Rural Water = 60 ac-ft Tri-County Rural = 460 ac-ft Combined Future Need = 1,490 ac-ft/yr Balance = 450 ac-ft/yr
Elk Valley Aquifer water available from transfer or reappropriation: 3,000 ac-ft/yr	Agassiz Rural Water = 50 ac-ft Langdon Rural = 320 ac-ft Walsh Water Users = 200 ac-ft Grand Forks-Traill = 2,550 ac-ft Combined Future Need = 3,120 ac-ft/yr Balance = -120 ac-ft/yr
Spiritwood Aquifer water available from new well field: 6,660 ac-ft/yr	Dakota Rural Water = 875 ac-ft Balance = 5,785 ac-ft/yr

Sheyenne Delta Aquifer - could be utilized by Cass Rural Water (1,450 ac-ft) to meet part of its shortage, Southeast Water Users (850 ac-ft), and Ransom Sargent (300 ac-ft). This equals the 2,600 ac-ft estimated to be available from irrigation water rights purchase.

Page/Galesburg Aquifer - could be utilized by Cass Rural Water(970 ac-ft) to meet the balance of its shortage, Traill (60 ac-ft), and Tri-County Rural Water (460 ac-ft). This combination uses 1490 ac-ft of the estimated 1940 ac-ft that may be available from transfers or reappropriation. Therefore, 450 ac-ft of irrigation water right would not be required for purchase, or could be considered available for small industrial purchase and use.

Elk Valley Aquifer - could be utilized by Agassiz (50 ac-ft), Langdon (320 ac-ft), Walsh (200 ac-ft), and Grand Forks-Traill (2,550 ac-ft). This total supply to rural water is 3,120 ac-ft per year. This is slightly over the estimate of 3,000 ac-ft available. However, the shortages listed for each rural water system are the high end demand estimate, so with only slightly less growth, or increased conservation measures, it could be sufficient to meet the shortage.

Spiritwood Aquifer - could be utilized by Dakota Rural Water (875 ac-ft). This potentially leaves 5,785 ac-ft available that could be provided to a municipal area or used to support a future commercial/industrial site. The estimated demand used for each future agricultural processing plant is 6,000 ac-ft per year under full demand and 5,100 ac-ft per year using a conservation demand. Therefore, the Spiritwood Aquifer could be considered to make up the future shortages of Dakota Rural Water and future industrial plant 5.

References

Pusc, Steven, 10/10/96, North Dakota State Water commission Office Memo, Water Permit Application #5022, Barnes Rural Water Users, Inc,

Cline, Odenbach, Schutt, Schuh, 1993, Feasibility of Stabilization of Water Levels and Expansion of Water Use From The Englevale Aquifer Using Water Conservation, Well Field Modification, and Artificial Recharge, North Dakota State Water Commission, Water Resource Investigation 23

Armstrong, C.A., 1982, Ground Water Resources of Ransom and Sargent Counties, North Dakota, U.S. Geological Survey County Ground Water Studies 31, Part III

Baker, Claud H., and Paulson, Q.F, 1967, Geology and Ground Water Resources Richland County, North Dakota, Part III, Ground Water Resources, North Dakota Geological Survey Bulletin 46, North Dakota State Water Commission, County Ground Water Studies 7.

Paulson, Q.F., Geologic Factors Affecting Discharge of the Sheyenne River in Southeastern North Dakota, Geological Survey Research, 1964.

Reclamation, 1997, Red River Valley Water Needs Assessment Administrative Draft Phase I Part A: MR & I Appraisal Report.

Klausing, Robert L, 1968, Geology and Ground Water Resources of Cass County, North Dakota, Hydrology, North Dakota State Water Commission County Ground Water Studies 8 - Part III

Western States Water Council, October 1990, Ground Water Recharge Projects in the Western United States: Economic Efficiency, Financial Feasibility and Legal/Institutional Issues. A Report to the Bureau of Reclamation and the Department of Interior.

Radig, Scott, 1994, North Dakota Geographic Targeting System for Groundwater Monitoring, North Dakota State Department of Health and Consolidated Laboratories, Division of Water Quality.

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May 10, 1995

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Denver, CO 80225-0007

Dear Mr. Burnett:

In response to your letter of April 18, 1995, 1 am enclosing copies of the appraisals of the major aquifers occurring in the Red River Valley. They include the Sheyenne Delta, West Fargo, Wahpeton/Colfax, Galesburg/Page, Elk Valley, Inkster, Grand Forks, and Emerado.

If you have questions regarding this information, please feel free to call or write.

Sincerely yours,

Milton 0. Lindvig, Director
Water Appropriation Division

MOL:mb/237 Encl.

GOVERNOR EDWARD T. SCHAFER
CHAIRMAN
DAVID A. SPRYNCZYNATYK, P.E.
SECRETARY & STATE ENGINEER

Wahpeton Buried Valley Aquifer

The Wahpeton buried valley (WBV) aquifer is located in the northeast portion of Richland County in southeastern North Dakota. The ancestral stream that eroded the Wahpeton buried valley entered North Dakota from the southeast about 2 mi north of the city of Wahpeton and exited north of the city of Abercrombie. The WBV aquifer underlies about 16 mi^2 between the cities of Wahpeton and Abercrombie and is comprised of fluvial deposits of sand and gravel between 140 to 300 ft below the ground surface. Water from the WBV aquifer is a calcium-magnesium bicarbonate type with an average total dissolved solids of about 650 mg/L.

The Wahpeton sand plain (WSP) aquifer overlies the WBV aquifer and consists of outwash deposits of silt, sand, and gravel between 80 to 140 ft below the ground surface. The areal extent of the WSP aquifer is wider than the WBV aquifer and in some locations there is direct hydraulic connection between the two aquifers.

The major water users from the WBV and WSP aquifers include the cities of Wahpeton and Breckenridge and the Minn-Dak Farmers Cooperative. Currently, 4 water permits allocate an annual withdrawal of 2480 acre-ft of ground water from the WBV and WSP aquifers for municipal and industrial use. This does not include an annual withdrawal of about 500 acre-ft of ground water for municipal use by the city of Breckenridge. There is potential for additional development within the WBV and WSP aquifers. However, future development is limited by the existing water rights and a pending water permit application for a significant volume of ground water for industrial use.

Colfax Aquifer

The Colfax aquifer is located in the northeast portion of Richland County and consists of buried outwash deposits of medium and coarse sand about 150 ft below the ground surface. Hydraulic properties of the Colfax aquifer are not known. However, many wells near the cities of Galchutt and Colfax have considerable head and many flow. Water from the Colfax aquifer is a sodium sulfate type with total dissolved solids of about 2400 mg/L. The chemical character of the water indicates hydraulic connection with the underlying Dakota Sandstone.

There are no major water users from the Colfax aquifer. However, future development is limited by the poor chemical quality of the ground water.

Emerado aquifer

The Emerado aquifer is a buried outwash aquifer which underlies about 15 square miles. It is composed of several feet of medium to coarse sand interspersed with the glacial till.

The Emerado aquifer is confined by glacial till to a depth of about 50 to 80 feet. The static piezometric surface is typically about 10 to 20 feet below land surface. The transmissivity is in the range of 1000 to 2000 ft2/day according to an aquifer test performed on a well completed in the aquifer. The storage coefficient is about 0. 000 1.

Water quality in the aquifer is generally poor. Leakage from the underlying Paleozoic formations have caused dissolved solids concentrations to typically be above 2000 mg/l. Water in this aquifer is not of suitable quality to serve as an alternative supply to existing water supplies in the Red River Valley.

Grand Forks aquifer

The Grand Forks aquifer is a small deeply buried sand and gravel deposit located in the vicinity of the City of Grand Forks. The aquifer is poorly defined. The depth of the aquifer is typically 200 feet and the thickness is probably less than 20 feet in most places. Glacial till and lake clays overlie the deposit. Water in the aquifer is highly mineralized with dissolved solids concentrations often exceeding 5000 mg/l. For this reason, the aquifer is not used as a water potable supply.

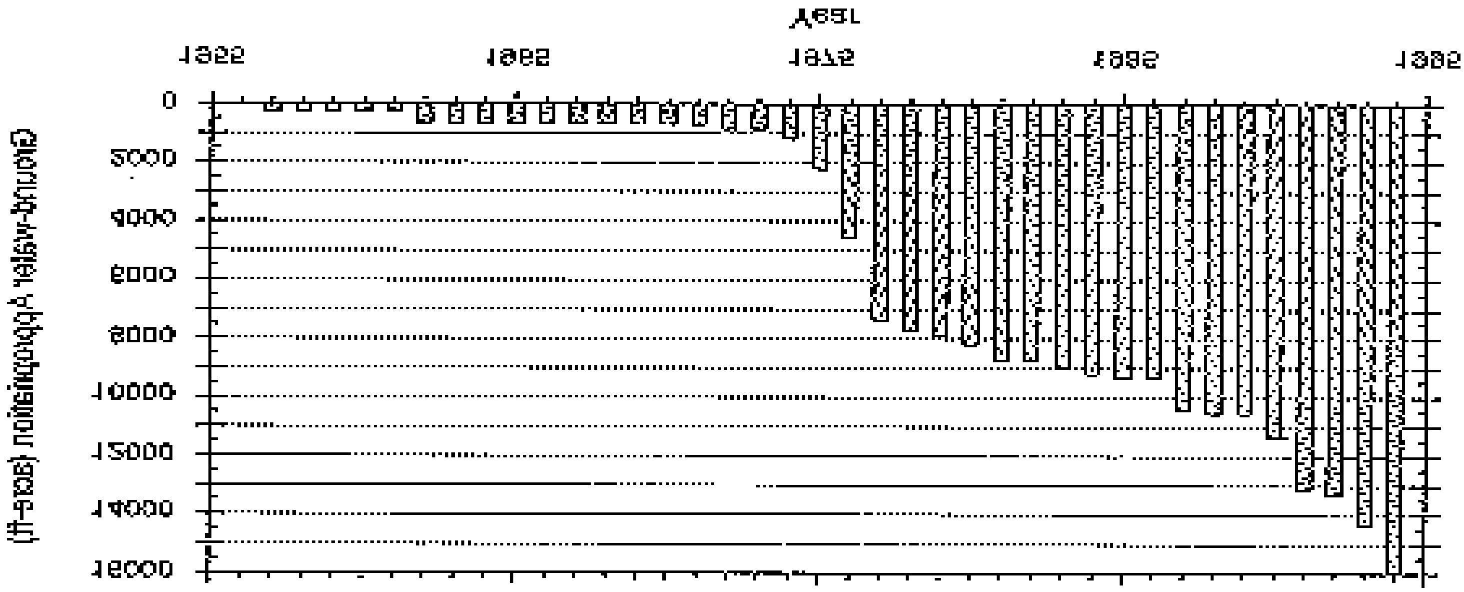
Sheyenne Delta Aquifer

The Sheyenne delta occupies about 750 mi^2 in Richland, Cass, Ransom, and Sargent Counties in southeastern North Dakota. The delta is comprised of sediments transported by the ancestral Sheyenne River and deposited into glacial Lake Agassiz during the Pleistocene Epoch. The delta is bordered on the north and east by lake sediments of glacial Lake Agassiz and on the south and west by till deposits. The Sheyenne River has eroded a valley about 100 ft deep through the delta deposits. The present river channel is sinuous and incised about 15 to 25 ft below the flood plain.

Sheyenne delta deposits can be divided into three units: 1) a lower unit of silt interbedded with clay and sand, 2) an upper unit of well sorted sand, and 3) a surficial layer of wind-blown sand. The lower silty unit is thickest near the northeastern margin of the delta and thins southwestward. The upper sand unit is thickest near the southwestern margin and thins northeastward. The Sheyenne delta aquifer is comprised of the upper unit of well-sorted deltaic sand and overlying wind-blown sand.

The Sheyenne delta aquifer is unconfined. An estimated 4 to 8 in of the annual 20 in of precipitation infiltrates as recharge to the aquifer. Ground-water discharge from the aquifer occurs primarily as groundwater inflow to the Sheyenne River and evapotranspiration. Depth to the water-table fluctuates between 2 to 10 ft below ground surface depending on precipitation and evapotranspiration. Hydraulic gradients range from as gentle as 5 ft per mile within the central portion of the aquifer to as steep as 100 ft per mile adjacent to the Sheyenne River valley.

Estimated transmissivity of the Sheyenne delta aquifer ranges between 288 and 1200 ft2 per day, based on an average saturated thickness of 40 ft and hydraulic conductivities of 7.2 and 30 ft per day for very fine to fine sand and fine to medium sand, respectively. Well yields range between 250 to 500 gpm in the southwestern portion of the aquifer and decrease to 50 to 250 gpm in the eastern and northern portions of the aquifer. Water from the Sheyenne delta aquifer is a calcium bicarbonate type with an average total dissolved solids of about 400 mg/L.



Currently, 61 water permits allocate an annual withdrawal of 15,900 acre-ft of ground water from the Sheyenne delta aquifer. Of the 61 permits, one is for a rural water supply and the rest are for irrigation. The greatest concentration of development is in the western portion of the aquifer. The potential for future development within the Sheyenne delta aquifer is dependent upon the following factors:

The effects on existing water rights.

The effect on the existing contribution of the aquifer to the base-flow of the Sheyenne River.

The well yield limitations in the eastern and northern portions of the aquifer.

The economic feasibility of constructing multiple well systems.

The accessibility and potential impacts on the National Grasslands.

There is potential for additional development within the Sheyenne delta aquifer. However, areas of future development are limited by the existing development in the western portion of the aquifer, the National Grasslands in the central portion of the aquifer, and decreasing well yield in the eastern and northern portions of the aquifer.

WEST FARGO AQUIFER SYSTEM

The West Fargo aquifer system is predominantly comprised of three separate, but interrelated aquifers. The West Fargo North (WFN) aquifer stretches north and south. and occurs from the bend in 1-94 (south of West Fargo) to several miles north-northeast of Harwood. The aquifer is generally 1 to 1 ½ miles wide, although the aquifer is 2 to 3 miles wide from Highway 10 to a couple of miles north of Highway 10. The West Fargo South (WFS) aquifer stretches north and south and occurs from just south of Highway 10 near 45th Street SW, south to the vicinity of St. Benedict (about 10 miles). The aquifer is about 1 to 1 1/4 miles wide the entire length. The Horace (HOR) aquifer is the westernmost aquifer of these three, and occurs from about 6 miles northwest of Horace to the Christine area trending south-southeast (a distance of about 20 to 25 miles). Another portion of the Horace aquifer occurs between the Christine area and two miles south of St. Benedict. The Horace aquifer is about three-fourths of a mile to a mile in width, except for the area near Christine where the two portions of the aquifer come together and the width is up to about 2 miles.

All three aquifers are buried channel aquifers consisting of glacial sand and gravel deposits. The WFS and HOR aquifers are generally found at depths of 80 to 370 feet, most commonly 150 to 300 feet in depth. The WFN aquifer occurs from 100 to 250 feet in depth, most commonly 100 to 200 feet in depth.

The WFN aquifer has been used significantly since the mid- 1930s. Water levels had declined from near land surface to near 120 feet below land surface by 1970. The HOR and the WFS aquifers slowly leaked into the WFN aquifer such that water levels of the HOR and WFS near the WFN aquifer were 40 to 50 feet below land surface in the mid 1960s, even though there was no significant use of the aquifers until the 1970s. Utilization of the WFS aquifer in the 1970s and 1980s have resulted in water levels declining to 60 to 115 feet below land surface depending on the distance from areas of higher use.

For the most part, the water quality of the HOR, WFN, and WFS aquifers can be broadly characterized as poor, medium, and good, respectively. The HOR aquifer is known to have total dissolved solids (TDS) varying from 600 to 1900 milligrams per liter (mgl), with most analyses about 1100 to 1350 mgl. The WFN aquifer has TDS values ranging from 600 to 1500 mgl with most analyses about 800 to 1050 mgl. The WFS aquifer has TDS values ranging from 375 to 700 mgl with most analyses about 450 to 600 ppm.

The West Fargo aquifer system is presently being studied. While the study is presently in progress and more interpretive work needs to be done, a couple of important factors are becoming quite clear. All parts of the aquifer system are experiencing water level declines. The declines are slow and not alarming, but the declines are historically persistent. The second factor is that preliminary analysis of stable isotope data indicates that there is very little, if any, recharge to the West Fargo aquifer system. These two factors indicate that the development potential of the West Fargo aquifer system is not promising.

PAGE/GALESBURG AQUIFER

The Page/Galesburg aquifer covers about 400 square miles located in three counties. In most recent reports and memos, this aquifer is generally referred to as the Page aquifer. The Page aquifer occurs in northwestern Cass County, southeastern Steele County and southwestern Traill County. The aquifer is predominantly unconfined in Steele and especially Traill. counties, and is predominantly leaky-confined to confined in Cass County. In Steele County the aquifer varies significantly between 80 to 200 feet in depth with water levels of 10 to 35 feet below land surface. In Traill County the aquifer is generally 40 to 100 feet in depth with water levels of about 5 to 25 feet. In Cass County the aquifer varies significantly between 100 to 250 feet in depth with water levels between 5 and 75 feet.

Over this large area a number of different depositional environments occur, but overall the sediment is predominantly fine to very fine sand grading into silt. In some areas, particularly in southeast Steele County, there are some coarser sands that are usually found toward the bottom of the aquifer section. In these areas wells yielding more than 500 gpm can be developed. In the topographically higher area of Cass County the saturated thickness of the aquifer is sometimes large enough (120+ feet) that 500-gpm wells can be developed even though the aquifer material is predominantly a very fine sand. In Traill County the shallow, unconfined, fine-grained nature of the aquifer generally means yields of a few hundred gpm at most.

The water quality of the Page aquifer is best in Cass County along a ridge of topographically high ground stretching generally north-south about 4 miles east of Page. The poorest water quality is in Steele County in an area between Colgate and Hope and stretching north. Even in the areas of poorest quality, the chloride levels do not exceed 50 mg/l, and generally they are below 10 mg/l in value. Virtually, all of the chemical analyses of water samples taken from observation wells located in Cass and Traill. counties in the Page aquifer show chlorides less than 10 mg/l.

About 15,000 acre-feet/year are allocated from the Page aquifer. About 68% of this allocation lies in Cass County, 27% in Steele, and 5% in Traill County. About 92% of this total allocation is for irrigation. The remainder is either municipal or rural water use. There are areas in all three counties where there is a potential for some additional development of water supplies, however significant portions of the Page aquifer in Cass County have limited development potential. Because of the potentially lower yielding wells in Traill County, any development there of a significant water supply would likely require multiple wells.

Inkster Aquifer

The Inkster aquifer is a glacial outwash deposit which underlies a flat to gently rolling plain. The aquifer has an overall areal extent of about 12 to 15 square miles. The lithology of the aquifer is generally a quartzose sand, detrital shale sand, and detrital bedrock and shield silicate gravels. The average saturated thickness is 20 to 50 feet. The Inkster aquifer is of similar geologic and hydrologic setting as the Elk Valley aquifer which lies directly to the west. The aquifers are separated by the long ridge-like Edinburg moraine. There does not appear to be any direct hydraulic connection between the two aquifers.

The aquifer is for the most part unconfined. There is typically no thick barrier of clay to impede the movement of water from the surface to the water table. The water table is generally 5 to 20 feet below land surface. The soils overlying the aquifers are generally sandy and highly transmissive. The soils readily absorb snowmelt and carry water to the aquifer as recharge. Also, summer and fall surplus rainfall, not taken by evapotranspiration, is recharged into the aquifer.

As a result of the highly permeable soils, there is little surface drainage over most of the aquifer as most of the surplus water is absorbed and moves downward rather than leaving as runoff.

Discharge from the aquifer occurs mainly by evaporation and plant transpiration during the growing season. Also, natural discharge occurs through springs and seeps where the North Branch of the Forest River transects the aquifer. A third means of discharge occurs from the pumping of high capacity wells for irrigation and rural water supply purposes.

Water samples obtained from the aquifers indicate a fairly good water quality. The TDS concentration is generally about 500 mg/I in this part of the aquifer. Sodium values are low, usually under 50 mg/l.

An aquifer test was performed on a well located at 154-055-23baa. The test was done on the "Groth" well in 1965. The aquifer parameters which were calculated from the 4500 minute test ranged from T=5500 to 9200 ft2/day and S = .13 to .22.

There are currently 12 active water permits which allow withdrawals from the Inkster aquifer for a total of 3586 acre-feet appropriated. Irrigation accounts for 83 percent.

Water level declines as a result of the water supply developments are very apparent. Because of the large existing appropriation from the aquifer in relation to its size, the Inkster aquifer should not be considered as a viable alternative source of supply for existing supplies.

Elk Valley Aquifer

The Elk Valley aquifer occupies about 200 square miles in the western portion of Grand Forks County. The aquifer was deposited during the Pleistocene epoch and is part of the Elk Valley Delta (Kelly and Paulson, 1970). The delta formed as eastern flowing drainage flowed into the western margin of the glacial Lake Agassiz basin. Lake Agassiz is dated in the latter part of the Pleistocene epoch about 10,000 to 15,000 years before present (Hansen and Kume, 1970). The aquifer is underlain by glacial drift deposits. The aquifer is bounded by the Pembina escarpment to the west, the Forest River on the north, and the Edinburg moraine in the northern portion of the east side. The aquifer pinches out in into the surrounding glacial drift deposits along the remaining perimeter on the south and east.

There is a general gradation from coarser materials in the north to finer materials in the south. The aquifer is generally unconfined with water table depths typically 5 to 15 feet below land surface. Soils on the point of diversion are generally sandy loams (Arvilla and Inkster series, Grand Forks County Soil Survey). These permeable soils along with the permeable aquifer deposits allow rainfall and snowmelt to be readily absorbed as recharge.

Ground water flow patterns are dominated by the discharge areas of the aquifer. The two predominant discharge mechanisms of the Elk Valley aquifer are springs and evapotranspiration. Springs and seeps occur where drainage depressions of rivers and ditches intersect with the water table of the aquifer. Evapotranspiration occurs where the water table is within a few feet of land surface such as around marshes and sloughs (Kelly and Paulson, 1970).

Four aquifer tests have been conducted on wells in the Elk Valley aquifer. The tests indicate that the transmissivity ranges from about 1,000 to 10,000 ft2/day. The specific yield ranges from about 0.12 to 0.20.

Water samples obtained from the aquifer indicate a fairly good water quality in most of the aquifer with Total Dissolved Solids (TDS) concentrations generally about less than about 500 mg/l. Higher TDS concentrations occur in the southern portion of the aquifer.

Presently, there are 63 permits which allocated 15,738 acre-feet of water from the Elk Valley aquifer. Irrigation water accounts for about 82 percent of the permitted appropriation. There are 37 permit applications totaling 14,152 acre-feet of water from the Elk Valley aquifer pending at the present time. Many of these applications have priority dates which date back to 1990 and 1991. Given the high level of existing development and the current number of pending water permit applications, the Elk Valley aquifer should not be considered as a possible alternative source for existing municipal water supplies in the Red River Valley.

CODE: D-8170

ESTIMATE WORKSHEET

SHEET OF

FEATURE: 22-Apr-99

FEATURE 8
Page/Galesburg
Water Rights Purchase

PROJECT: Red River Valley Water Supply

DIVISION:

FILE: J:\REDRIVER\RROWELLS.WK4

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT	LIFE	Annual Operation	Annual Maintenance	Annual Replacement	Annual Energy	TOTAL ANNUAL
		Drill & install wells with stainless steel casings and screens											
		8-inch dia., 105-feet deep, 15-foot screened (average)		8	EA	$25,000.00	$200,000.00	50+	$25,000.00	$15,000.00			$40,000.00
		Furnish and install pumps for wells											
		45 HP		1	EA	$7,000.00	$7,000.00	15			$800.00		$800.00
		35 HP		3	EA	$6,500.00	$19,500.00	15			$2,100.00		$2,100.00
		30 HP		2	EA	$6,000.00	$12,000.00	15			$1,300.00		$1,300.00
		20 HP		2	EA	$5,000.00	$10,000.00	15			$1,100.00		$1,100.00
		Furnish and install wellfield control/monitoring equipment		1	LS	$200,000.00	$200,000.00	10			$14,200.00		$14,200.00
		Furnish and install watertank (250,000 gallon)		1	LS	$225,000.00	$225,000.00	50+					
		Furnish and install pipe with earthwork & ROW costs											
		18B100	PVC	37.0	miles	$230,000.00	$8,510,000.00	50+			$6,100.00		$6,100.00
		15B200	PVC	8.0	miles	$176,000.00	$1,408,000.00	50+			$1,000.00		$1,000.00
		12B250	PVC	5.0	miles	$146,000.00	$730,000.00	50+			$500.00		$500.00
		10B250	PVC	1.0	miles	$101,000.00	$101,000.00	50+			$100.00		$100.00
		8B250	PVC	2.5	miles	$77,000.00	$192,500.00	50+			$100.00		$100.00
		6B300	PVC	2.0	miles	$55,000.00	$110,000.00	50+			$100.00		$100.00
		Air Valve Installations (2 per mile)		111	EA	$5,000	$555,000.00	50+					
		Blowoff Installations (2 per mile)		111	EA	$8,000	$888,000.00	50+					
		Overhead powerlines for wellfield		5	miles	$40,000.00	$200,000.00	45			$14,500.00		$14,500.00
		Pipe Jacking (15" carrier pipe X 100')		1	EA	$30,000	$30,000.00	50+					
		Pipe Jacking (18" carrier pipe X 100')		1	EA	$34,000	$34,000.00	50+					
		Pipe Jacking (21" carrier pipe X 100')		5	EA	$38,000	$190,000.00	50+					
		Telemetry		1	LS	$400,000.00	$400,000.00	10			$28,300.00		$28,300.00
								Subtotal	$25,000.00	$15,000.00	$70,200.00		$110,200.00
		Mobilization (+/- 5%)					$700,000.00						
		SUBTOTAL					$14,722,000.00				Unlisted Items (+/- 20%)		$19,800.00
		Unlisted Items (+/- 20%)					$2,778,000.00						
		CONTRACT COST					$17,500,000.00				**TOTAL O, M, R, & E**		**$130,000.00**
		Contingencies (+/- 25%)					$4,500,000.00						
		FIELD COST					$22,000,000.00						
		USBR Invest., Mitig., Engr. & Constr. Mgt. (+/- 33%)					$7,000,000.00						
		TOTAL ESTIMATE					**$29,000,000.00**				**ANNUALIZED CAPITAL COST**		**$2,070,000.00**

QUANTITIES		PRICES			
BY R. Burnett		BY RKC K. Copeland	CHECKED Craig A. Gusk 4/23/99	**TOTAL ANNUAL COST**	**$2,200,000.00**
DATE PREPARED	APPROVED	DATE 4/22/99	PRICE LEVEL Appraisal		

CODE: D-8170

ESTIMATE WORKSHEET

SHEET OF

FEATURE: 23-Apr-99

FEATURE 8
Sheyenne Delta Aquifer
Water Rights Purchase

PROJECT: Red River Valley Water Supply

DIVISION:

FILE: J:\REDRIVER\RROWELLS.WK4

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT	LIFE	Annual Operation	Annual Maintenance	Annual Replacement	Annual Energy	TOTAL ANNUAL
		Drill & install wells with stainless steel casings and screens											
		8-inch dia., 70-feet deep, 10-foot screened (average)		7	EA	$17,500.00	$122,500.00	50+	$25,000.00	$15,000.00			$40,000.00
		Furnish and install pumps for wells											
		45 HP		1	EA	$7,500.00	$7,500.00	15			$800.00		$800.00
		35 HP		2	EA	$6,500.00	$13,000.00	15			$1,400.00		$1,400.00
		30 HP		2	EA	$6,000.00	$12,000.00	15			$1,300.00		$1,300.00
		25 HP		1	EA	$5,500.00	$5,500.00	15			$600.00		$600.00
		20 HP		1	EA	$5,000.00	$5,000.00	15			$500.00		$500.00
		Furnish and install wellfield control/monitoring equipment		1	LS	$210,000.00	$210,000.00	10			$14,900.00		$14,900.00
		Furnish and install pipe with earthwork & ROW costs											
		15B100	PVC	1.5	miles	$171,000.00	$256,500.00	50+			$200.00		$200.00
		12B100	PVC	6.0	miles	$131,000.00	$786,000.00	50+			$600.00		$600.00
		10B100	PVC	1.7	miles	$85,000.00	$144,500.00	50+			$100.00		$100.00
		6B150	PVC	4.1	miles	$55,000.00	$225,500.00	50+			$200.00		$200.00
		Air Valve Installations (2 per mile)		27	EA	$5,000	$135,000.00	50+					
		Blowoff Installations (2 per mile)		27	EA	$8,000	$216,000.00	50+					
		Overhead powerlines for wellfield		5	miles	$40,000.00	$200,000.00	45			$14,500.00		$14,500.00
		Outlet Works (3.5 cfs)		1	LS	$40,000.00	$40,000.00	50+					
		Pipe Jacking (8" carrier pipe X 100')		1	EA	$21,000	$21,000.00	50+					
		Pipe Jacking (15" carrier pipe X 100')		2	EA	$30,000	$60,000.00	50+					
		Telemetry		1	LS	$150,000.00	$150,000.00	10			$10,600.00		$10,600.00
								Subtotal	$25,000.00	$15,000.00	$45,700.00		$85,700.00
✓		Mobilization (+/- 5%)					$130,000.00						
✓		SUBTOTAL					$2,740,000.00				Unlisted Items (+/- 20%)		$14,300.00
✓		Unlisted Items (+/- 20%)					$560,000.00						
✓		CONTRACT COST					$3,300,000.00				**TOTAL O, M, R, & E**		**$100,000.00**
✓		Contingencies (+/- 25%)					$800,000.00						
✓		FIELD COST					$4,100,000.00						
✓		USBR Invest., Mitig., Engr. & Constr. Mgt. (+/- 33%)					$1,400,000.00						
✓		**TOTAL ESTIMATE**					**$5,500,000.00**				**ANNUALIZED CAPITAL COST**		**$390,000.00**
											TOTAL ANNUAL COST		**$490,000.00**

QUANTITIES		PRICES	
BY R. Burnett		BY RKC K. Copeland	CHECKED Craig A. Glenn 4/23/99
DATE PREPARED	APPROVED	DATE 4/23/99	PRICE LEVEL Appraisal

CODE: D-8170

ESTIMATE WORKSHEET

SHEET OF

FEATURE: 22-Apr-99

FEATURE 8
Elk Valley Aquifer
Water Rights Purchase

PROJECT: Red River Valley Water Supply

DIVISION:

FILE: J:\REDRIVER\RROWELLS.WK4

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT	LIFE	Annual Operation	Annual Maintenance	Annual Replacement	Annual Energy	TOTAL ANNUAL
		Drill & install wells with stainless steel casings and screens											
		8-inch dia., 50-feet deep, 10-foot screened (average)		16	EA	$13,000.00	$208,000.00	50+	$40,000.00	$30,000.00			$70,000.00
		Furnish and install pumps for wells											
		15 HP		3	EA	$4,000.00	$12,000.00	15			$1,300.00		$1,300.00
		10 HP		7	EA	$3,250.00	$22,750.00	15			$2,500.00		$2,500.00
		7.5 HP		3	EA	$3,000.00	$9,000.00	15			$1,000.00		$1,000.00
		5 HP		3	EA	$2,500.00	$7,500.00	15			$800.00		$800.00
		Furnish and install wellfield control/monitoring equipment		1	LS	$310,000.00	$310,000.00	10			$21,900.00		$21,900.00
		Furnish and install watertank (250,000 gallon)		1	LS	$225,000.00	$225,000.00	50+					
		Furnish and install pipe with earthwork & ROW costs											
		18B100	PVC	16.8	miles	$230,000.00	$3,864,000.00	50+			$2,800.00		$2,800.00
		15B100	PVC	15.2	miles	$171,000.00	$2,599,200.00	50+			$1,900.00		$1,900.00
		12B175	PVC	7.5	miles	$131,000.00	$982,500.00	50+			$700.00		$700.00
		10B275	PVC	7.0	miles	$101,000.00	$707,000.00	50+			$500.00		$500.00
		8B300	PVC	2.0	miles	$82,000.00	$164,000.00	50+			$100.00		$100.00
		6B350	PVC	2.0	miles	$64,000.00	$128,000.00	50+			$100.00		$100.00
		4B275	PVC	3.3	miles	$53,000.00	$174,900.00	50+			$100.00		$100.00
		3B275	PVC	2.0	miles	$50,000.00	$100,000.00	50+			$100.00		$100.00
		Air Valve Installations (2 per mile)		111	EA	$5,000	$555,000.00	50+					
		Blowoff Installations (2 per mile)		111	EA	$8,000	$888,000.00	50+					
		Overhead powerlines for wellfield		5	miles	$40,000.00	$200,000.00	45			$14,500.00		$14,500.00
		Pipe Jacking (12" carrier pipe X 100')		1	EA	$27,000	$27,000.00	50+					
		Pipe Jacking (15" carrier pipe X 100')		2	EA	$30,000	$60,000.00	50+					
		Pipe Jacking (18" carrier pipe X 100')		3	EA	$34,000	$102,000.00	50+					
		Pipe Jacking (21" carrier pipe X 100')		4	EA	$38,000	$152,000.00	50+					
		Telemetry		1	LS	$275,000.00	$275,000.00	10			$19,500.00		$19,500.00
								Subtotal	$40,000.00	$30,000.00	$67,800.00		$137,800.00
		Mobilization (+/- 5%)					$590,000.00						
		SUBTOTAL					$12,362,850.00				Unlisted Items (+/- 20%)		$32,200.00
		Unlisted Items (+/- 20%)					$2,637,150.00						
		CONTRACT COST					$15,000,000.00				**TOTAL O, M, R, & E**		**$170,000.00**
		Contingencies (+/- 25%)					$3,500,000.00						
		FIELD COST					$18,500,000.00						
		USBR Invest., Mitig., Engr. & Constr. Mgt. (+/- 33%)					$6,500,000.00						
		TOTAL ESTIMATE					**$25,000,000.00**				**ANNUALIZED CAPITAL COST**		**$1,780,000.00**
											TOTAL ANNUAL COST		**$1,950,000.00**

QUANTITIES		PRICES	
BY R. Burnett		BY K. Copeland	CHECKED Craig A. Gush 4/23/99
DATE PREPARED	APPROVED	DATE 4/22/99	PRICE LEVEL Appraisal